IDENTIFICATION, SEASONAL POPULATION AND CHEMICAL CONTROL OF CITRUS APHIDS OF TAIWAN

by

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Citrus virus "Tristeza" has been discovered and its damage is so badly over this island. The transmission methods have been proved by grafting diseased scion from uncertified mother tree and insect vector "aphids.". Therfore the administration of healthy mother tree (free of tristeza) and citrus aphid control being ranked two important works for reducing tristeza damage.

The following results were obtained from past two years (1959–60) observation. The writers wish to express their hearty thanks to Dr. Ting-wei Lew and T. T. Lo of Joint Commision on Rural Reconstruction and Dr. S. C. Hsu, Director of Taiwan Agricultural Research Institute for approving and supervising this study, without them the present paper would not be completed.

I. CITRUS APHID IDENTIFICATION

There are seven species of citrus aphids recorded from this island. They may be separated by the following key.

1. Key to species of Citrus aphids (Figs. 1–8)

1. Frontal tubercles very developed. Siphunculi more or less swollen. Body brown or green ..... 2.
   Frontal tubercles present but not very developed. Siphunculi cylindrical, never swollen ..... 3.
2. Frontal tubercles diverging, smooth. Third antennal segment of aptera with one or two rhinariae near the base. Siphunculi as long as the cauda, smooth, scarcely imbricated on the distal half, with some striae near the flange. Cauda slightly constricted at basal one-third, long and stout, acuminate, apex rounded, with five to nine lateral hairs. Body shining brown. Occasionally on Citrus.....
   .....*Sinomegoura citricola* (van der Goot)
   Frontal tubercles converging, inward on mesal side, spinulose. Third antennal segment of aptera without rhinaria. Siphunculus is much longer than cauda, cylindrical or swollen at apical third. Cauda somewhat constricted at or near middle and acuminate at apex, with three lateral hairs. Abdomen with a large more or less solid black patch. Body green, light pink or pale. Occasionally on Citrus ..... *Myzus persicae* (Sulzer)
3. With a stridulating mechanism which consisting of a row short hairs on the

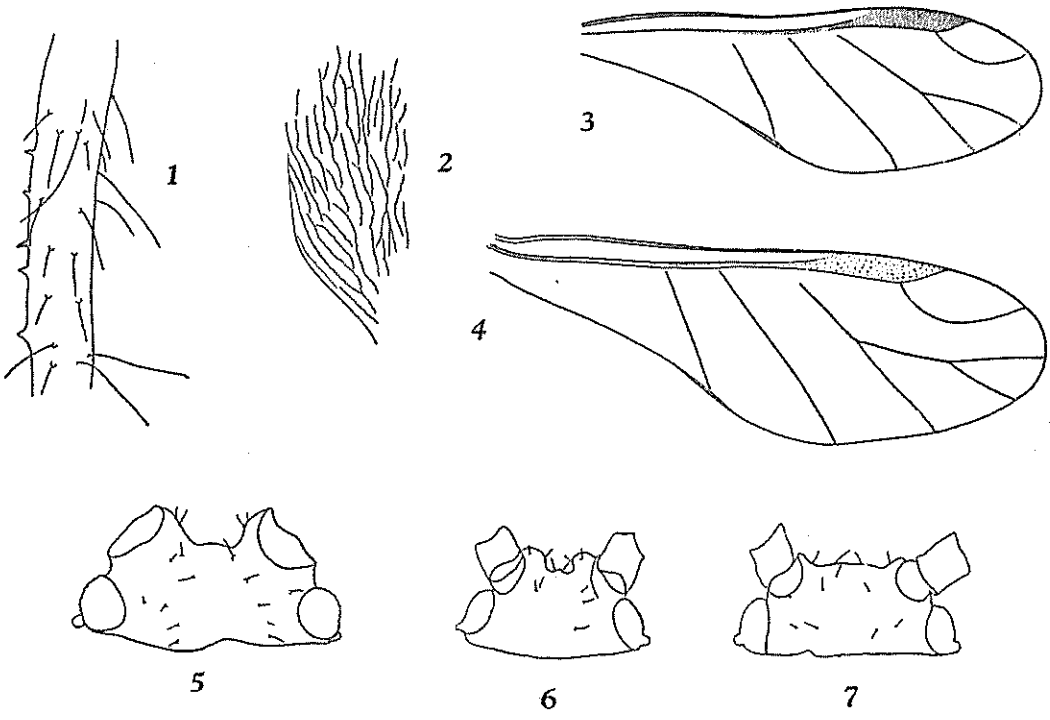

Fig. 1. 1. Part of hind tibia, 2. Part of abdomen of *Toxoptera citricidus*, showing the stridulating mechanism, 3. Fore wing of *T. aurantii*, 4. Fore wing of *T. citricidus*, 5, 6, 7, Head of *Sinomegoura citricola* (without first antennal segment), *Myzus persicae*, *T. citricidus* (with first antennal segment).

hind tibia and a latero-ventral abdominal pattern of raised and serrated cuticle on sternites 5 and 6. Body brown or black..... 4.
Without a stridulating mechnism. Body greenish yellow or gray..... 6.

4. Antennal hairs prominent and a little longer than its diameter of the segment. Siphunculus is much shorter than cauda and nearly as long as the base of sixth antennal segment. Body brown. Very rarely on Citrus.....
..... *Toxoptera odinae* (van der Goot)
Antennal hairs are shorter than its diameter of the segment. Siphunculus is at least longer than the base of sixth antennal segment. Body shining black.... 5.

5. Body comparatively small. Third antennal segment of alate pale except at the very apex and having 2 to 8 rhinariae, arranged in a single row and extending to the whole length, fourth segment without rhinaria. Media of forewing once branched ..... *Toxoptera aurantii* (Boyer)
Body comparatively large. Third antennal segment of alate black, except for the very base and bearing 7 to 24 rhinariae, fourth segment with 0-9 rhinariae, the rhinariae are not arranged in a single row and irregularly extended to the most area except both ends. Media of fore wing twice branched.....
..... *Toxoptera citricidus* (Kirkaldy)

6. Fourth antennal segment of alate somewhat with 0–4 rhinariae. Cauda with more than 3 lateral hairs. Body greenish yellow. Usually living within curl leaves.....*Aphis spiraecola* Patch
Fourth antennal segment of alate without rhinaria. Cauda usually with 3 lateral hairs. Body gray. Living on opened leaves .....*Aphis gossypii* Glover

2. Notes on Citrus aphids

(1) *Sinomegoura citricola* (van der Goot, 1917) (Fig. 2)

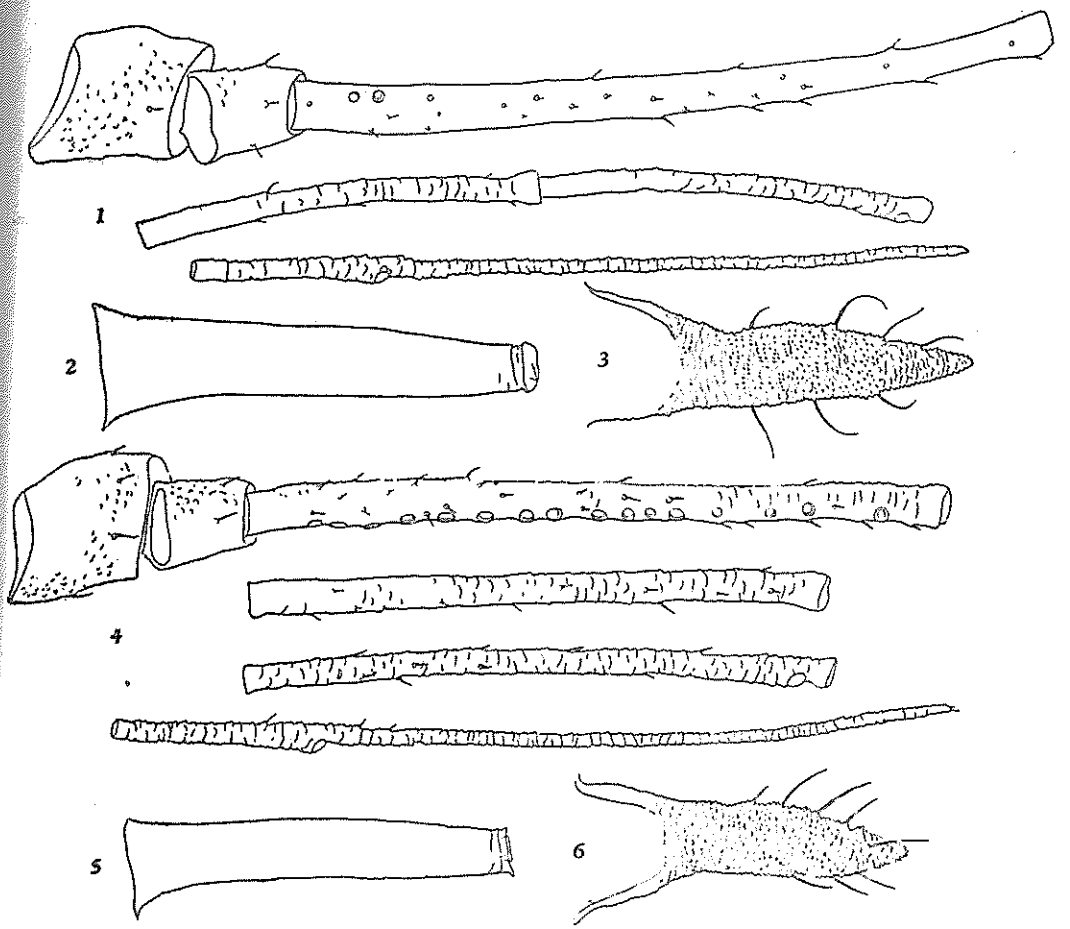

Fig. 2. *Sinomegoura citricola* (van der Goot)
1. 2. 3. Antenna, siphunculus and cauda of aptera; 4. 5. 6. Antenna, siphunculus and cauda of alate.

Synonyms: *Macrosiphoniella citricola* van der Goot, 1917; *Tuberosiphum camphorae* Shinji, 1922; *Megoura jacobsoni* Mason, 1927.

Hosts: Burseraceae: *Canarium album;* Camelliacceae: *Camellia japonica;* Caesalpiniaceae: *Bauhinia variegata;* Euphorbiaceae: *Bridelia ovata;* Lauraceae: *Cin-*

namomum champhora, Litsea sp.; Moraceae: *Ficus obscura;* Palmae: *Trachycarpus excilsus;*Rubiaceae: *Lasianthus* sp.; Rutaceae: *Acronychia pedunculata, Citrus* spp., *Murraya exotica.*

This species is first recorded on *Citrus* spp. from this island, but the infestation is not so severe as *Toxoptera* spp. or *Aphis* spp. and whether tranmission tristeza or not is waiting for test. Dr. Takahashi first recorded and it was taken on Citrus from Taitung on May 16, 1935 but he did not publish it yet. This species is very common on *Murraya exotica* in winter and spring near Taipei.

Distribution: China: Taiwan, Kwangtung, and Fuckien; Japan and Java.

(2) *Myzus persicae* Sulzer 1776 (Fig. 3)

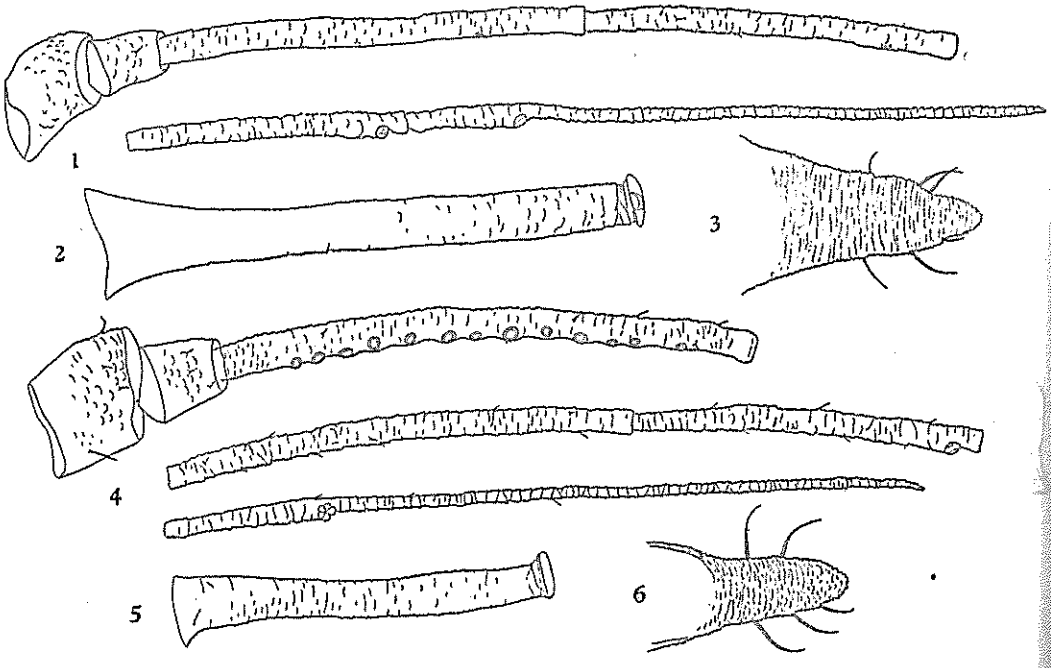

Fig. 3. *Myzus persicae* Sulzer

1. 2. 3. Antenna, siphunculus and cauda of aptera; 4. 5. 6. Antenna, siphunculus and cauda of alate.

Synonyms: *Myozoides persicae* van der Goot, 1913; *Rhopalosiphum persicae* Matsumura, 1917.

Hosts; Aceraceae: *Acer* sp.; Apocynaceae: *Nerium indicum;* Borraginaceae: *Bothriospermum chinense;* Caryophyllaceae: *Stellaria aquatica;* Chenopodiaceae: *Chenopodium album;* Compositae: *Chrysanthemum* sp., *Lactuca oldhami, L. sativa, Petasites tricholobus, Senecio cineravia;* Convolvulaceae: *Ipomoea batatas, I. cairica, Merremia gemella;* Cruciferae: *Brassica campestris, B. chinensis, B. napus, Capsella bursapastoris, Raphanus sativus, R.* sp.; Leguminose: *Pisum sativum;* Malvaceae: *Abelmoschus moschatus, Hibiscus albomoschus;* Myrtaceae: *Eucalyptus robusta, Psid-*

ium guajava; Papaveraceae: *Papaver somniferum;* Pedaliaceae: *Sesamum indicum;* Polygonaceae: *Polygonum multiflorum;* Rosaceae: *Prunus persica, P. mume;* Rutaceae: *Citrus spp.;* Scrophulariaceae: *Antirrhinum majus;* Solanaceae: *Lycium chinensis, Nicotiana tabacum, Solanum melongena, S. tuberosum;* Ulmaceae: *Zelkova formosana;* Verbenaceae: *Duranta plumieri.*

It rarely infests on *Citrus* spp. whether transmission tristeza or not is waiting for test but it is a major insect vector of other viruses of cultivated and wild plants and is a major tobacco, brassica pests on this island.

Distribution: China: Hainan, Taiwan, Kwangtung, Fuckien, Chekiang, Kiangsu, Shantung, Hopei, Liaoning, Szechuan and Sikong. This is a cosmopolitan species.

(3) *Aphis gossypii* Glover 1876 (Fig. 4)

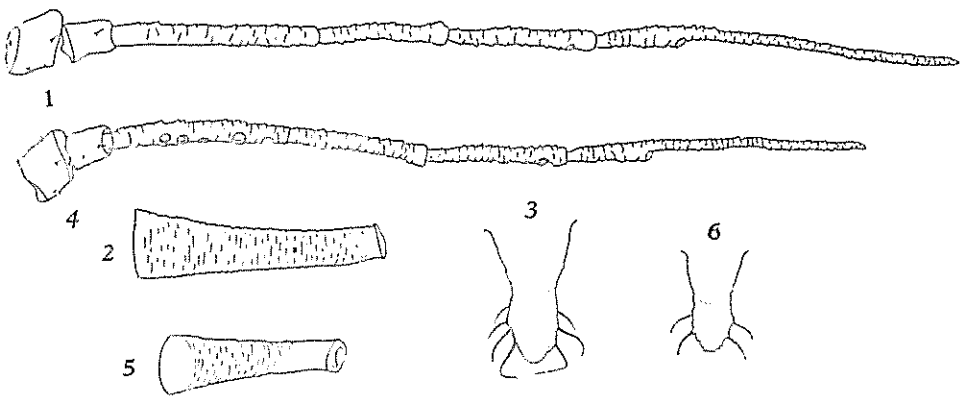

Fig. 4. *Aphis gossypii* Glover

1. 2. 3. Antenna, siphunculus and cauda of aptera; 4. 5. 6. Antenna, siphunculus and cauda of alate.

Synonyms: *Toxoptera odorikonis* Matsumura, 1917; *Aphis clerodendori* Matsumura 1917; *A. colocasiae* Matsumura, 1917; *A. malvae* Takahashi, 1921; *Toxoptera leonuri* Takahashi, 1921; *A. shirakii* Takahashi, 1921; *A. gossypii var. callicarpae* Takahashi, 1921; *A. vitifoliae* Shinji, 1922; *A. inugomae* Shinji, 1922; *A. bryoplyllae* Shinji, 1922; *A. hibiscifoliae* Shinji, 1922.

Hosts: Acanthaceae: *Justicia procumbens;* Araceae: *Caladium colocasia, Colocasia antiquorum, C. kotoensis;* Araliaceae: *Acanthopanax trifoliatum;* Bombaceae: *Bombax ceiba* Linn.; Casuarinaceae: *Casuarina equisetifolia;* Cammelinaceae: *Cammelina nudiflora;* Compositae: *Bidens pilosa, Blumea balsamifera. Chrysanthemum sinensis, C.* sp., *Cirsium segtum, Erigeron linifolius, Gnaphalium* sp., *Lactuca debilis;* Cruciferae: *Capsella bursapastoris;* Cucurbitaceae: *Citrullus vulgaris, Cucumis sativus, Cucurbita maxima, C. pepo;* Euphorbiaceae: *Breynia* sp., *Euphorbia hirta, E.* sp., *Phyllanthus reticulatus;* Hamamelidaceae: *Liquidambar formosana;* Libiatae: *Leonurus sibiricus, Perilla ocymoides, Salvia coccinea, Marubium supinum;* Leguminosa: *Bauhinia blakeana, Glycine hispida, Medicago sativa;* Lythraceae: *Lawsonia*

inermis; Magnoliaceae: *Magnolia deundata;* Malvaceae: *Abelmoschus esculentus, A, moschatus, Gossypium* spp., *Hibiscus rosasinensis, H.* sp., *H. syriacus;* Melastomataceae: *Melastoma candidum;* Moraceae: *Broussonetia papyrifera, Ficus* sp.,; Myrtaceae: *Eucalyptus* sp., *Eugenia jambos, Psidium guajava;* Nyctaginaceae: *Bougainvillaea spectabilis;* Polygonaceae: *Antigonon leptopus, Fagopyrum esculentum;* Portulaceae: *Portulaca oleracea;* Punicaceae: *Punica grantum;* Rosaceae: *Chaenomeles lagenaria, Eriobotrya japonica, E.* sp., *Malus* sp., *Pirus serotina;* Rubiaceae: *Gardenia jasminoides, Ixora chinensis, Ourouparis formosana, Rubia cordifolia;* Rutaceae: *Citrus* spp., *Zanthoxylum bungei, Z. simulans;* Saliaceae: *Salix babylonia, S. warburgi;* Scrophulariaceae: *Paulownia tomentosa;* Solanaceae: *Lycoperscum esculentum melongena, S. torvum, S. tuberosum;* Urtiaceae: *Boehmeria nivea;* Valerianaceae *Valeriana valerianfolia;* Verbenaceae: *Callicarpa formosana, Clerodendron fortunnatum, C.* sp., *C. taichotomum, Tectona grandis. Vitex cannabiformis.*

It is occasionally found on *Citrus* spp. and the colour usually is gray but from other hosts, its colour is usually light yellow.

Distribution: China: Hainan, Taiwan, Kwangtung, Fuckien, Chekiang, Kiangsu, Shantung, Hopei, Liaoning, Szechuan, Sikong. This is a cosmopolitan species.

(4) *Aphis spiraecola* Patch 1914 (Fig. 5)

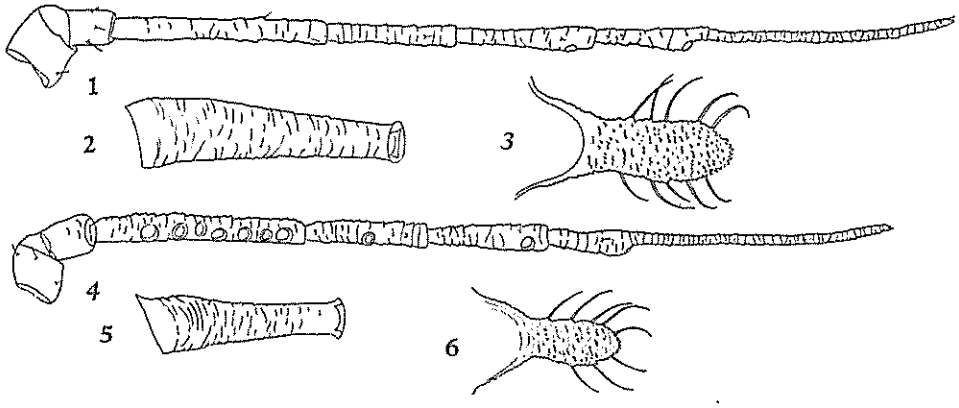

Fig. 5. *Aphis spiraeccola* Patch

1. 2. 3. Antenna, siphunculus and cauda of aptera; 4. 5. 6. Antenna, siphunculus and cauda of alate.

Synonyms: *Aphis pomi* Takahashi nec De Geer.

Hosts: *Spiraea cantonensis, S.* sp., *Dodonaea viscosa* Jacq. the last host was discovered by Dr. Evert I. Schlinger.

This species comes to near *Aphis pomi* De Geer, 1773, but *A. pomi* does not feed on *Citrus* spp.

Distribution: China: Taiwan, Kwangtung, Fuckien. Formerly known from United States of America.

(5) *Toxoptera odinae* (van der Goot, 1917) (Fig. 6)

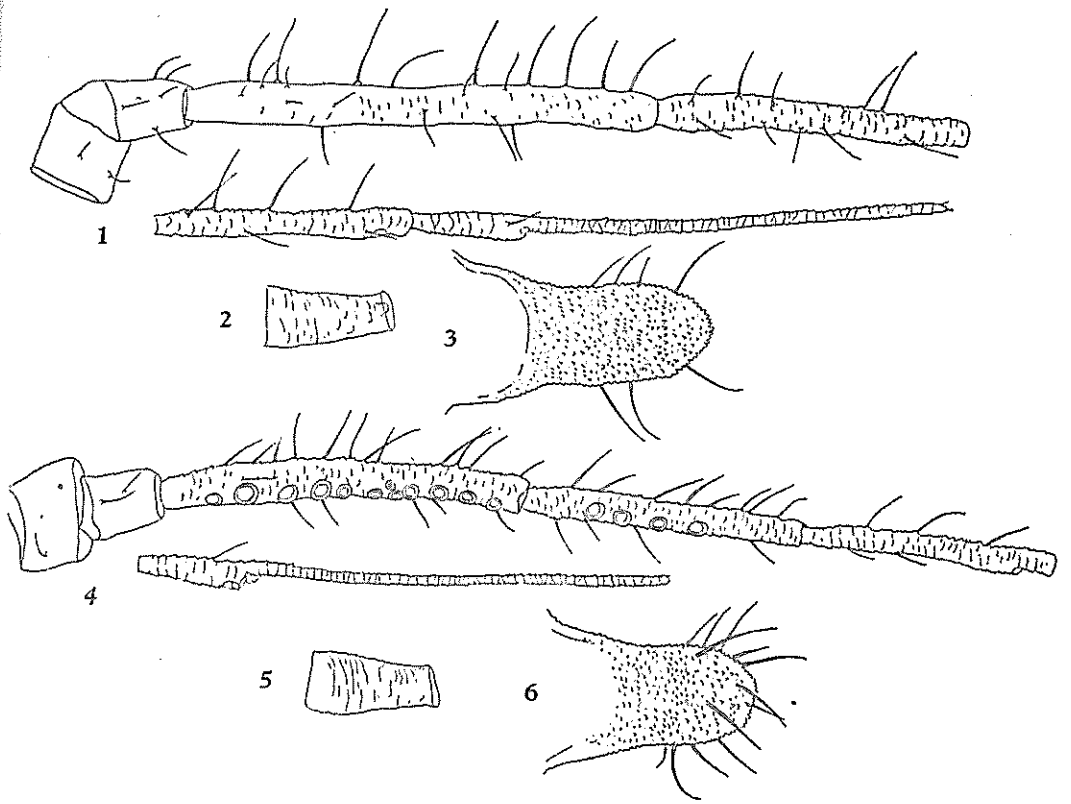

Fig. 6. *Toxoptera odinae* (van der Goot)
1. 2. 3. Antenna, siphunculus and cauda of aptera; 4. 5. 6. Antenna, siphunculus and cauda of alate.

Synonyms: *Longiungius odinae* van der Goot, 1917; *Arimakia araliae* Matsumura, 1917; *Arimakia taranbonis* Matsumura, 1917; *Aphis somei* Essig et Kuwana, 1918; *Aphis ficicola* Takahashi, 1921; *Aphis rutae* Shinji, 1922; *Aphis mokulen* Shinji. 1922; *Somaphis somei* Shinji, 1929; *Somaphis sansho* Shinji, 1932.

Hosts: Anacardiaceae: *Mangifera indica, Rhus chinensis, R. semialata;* Araliaceae: *Acanthopanax trifoliatum, Agalma lutchuense;* Burseraceae: *Canarium album;* Caprifoliaceae: *Viburnum formosanum, V. odoratissimum, V.* sp.; Euphorbiaceae: *Bischofia javanica, Fluggea virosa, Sapium sebiferum;* Moraceae: *Ficus wrightiana;* Guttiferae: *Garcinia multiflorae;* Myrtaceae: *Eucalyptus robusta;* Pittosporaceae: *Pittosporum tobira;* Polygonaceae: *Polygonum multiflorum;* Rubiaceae: *Wendlandia paniculata;* Rutaceae: *Citrus* spp., *Zanthoxylum nitidum.*

This species is rarely found on *Citrus* spp.

Distribution: Taiwan, Kwangtung, Fuckien, Chekiang, Kiangsu, Szechuan, Honan; Korea, Japan, India, Thailand, Malaya, Sumatra.

(6) *Toxoptera aurantii* (Boyer de Fonscolombe, 1841) (Fig. 7)

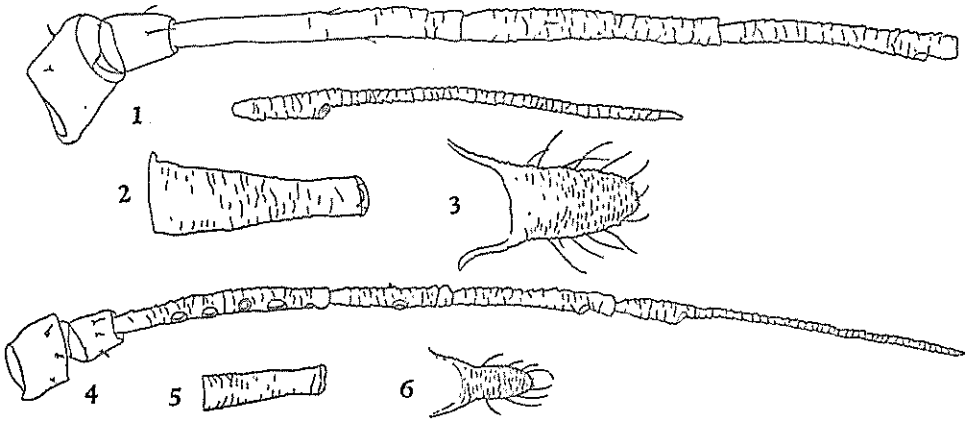

Fig. 7. *Toxoptera aurantii* (Boyer)
1. 2. 3 Antenna, siphunculus and cauda of aptera; 4. 5. 6. Antenna, siphunculus and cauda of alate.

Synonyms: *Aphis aurantii* B. d. F., 1841; *Aphis camelliae* Kaltenbach, 1843; *Toxoptera aurantiae* Koch, 1857; *Aphis coffeae* Nietner, 1861; *Myzus* (*Ceylona*) *theaecola* Buckton, 1891; *Toxoptera theobromae* Schouteden, 1906; *Aphis citrifoliae* Shiraki, 1913; *Toxoptera alaterni* De Geer, 1909; *Toxoptera variegata* Del Guercio, 1909; *Toxoptera aurantii limonii* Del Guercio, 1914; *Aphis coffeae thomensis* De Seabra, 1921.

Hosts: Anachardiaceae: *Mangifera indica;* Annonaceae: *Annona onuricata, A.* sp.; Apocynaceae: *Trachelospermum jasminoides;* Aquifoliaceae: *Ilex rotunda;* Araceae: *Caladium* sp.; Borraginaceae: *Ehretia buxifolia, E. microphylla;* Camelliaceae: *Thea chinensis, T. japonica, T.* sp., *T. caudata;* Caprifoliaceae: *Viburnum odoratissimum;* Euphorbiaceae: *Macaranga tanarius;* Fagaceae: *Quercus* sp.; Flacourtaceae: *Scolopia crenata, Xylosma racemosium var. kwangtungensis; F. fovolata,* Moraceae: *Artocarpus integra, Cassia glauca, Ficus akeotsang, F. pumila, F. retusa, Morus alba, M, australis, M. bombycis;* Myrtaceae: *Eucalytus rubusta, Maesa tenera;* Pittosporaceae: *Pittosporum tobira;* Rhamnaceae: *Sageretia theezans;* Rutaceae: *Acronychia pedunculata, Citrus* spp., *Murraya exotica, M. augusta, M. paniculata;* Rubiaceae: *Coffea arabica, Gardenia florida, G. jasminoides, Randia sinensis, R. spinosa;* Saliaceae: *Salix babylonica, S. warburgi;* Styracaceae: *Styrax suberifolium;* Sterculiaceae: *Theobroma cacao;* Ulmaceae: *Zelkova schneideriana;*

It is very common on *Citrus* spp. over the island.

Distribution: China: Taiwan, Kwangtung, Fuckien, Chekiang, Szechuan; Other tropical and subtropical countries.

(7) *Toxptera citricidus* (Kirkaldy, 1907) (Fig. 8)

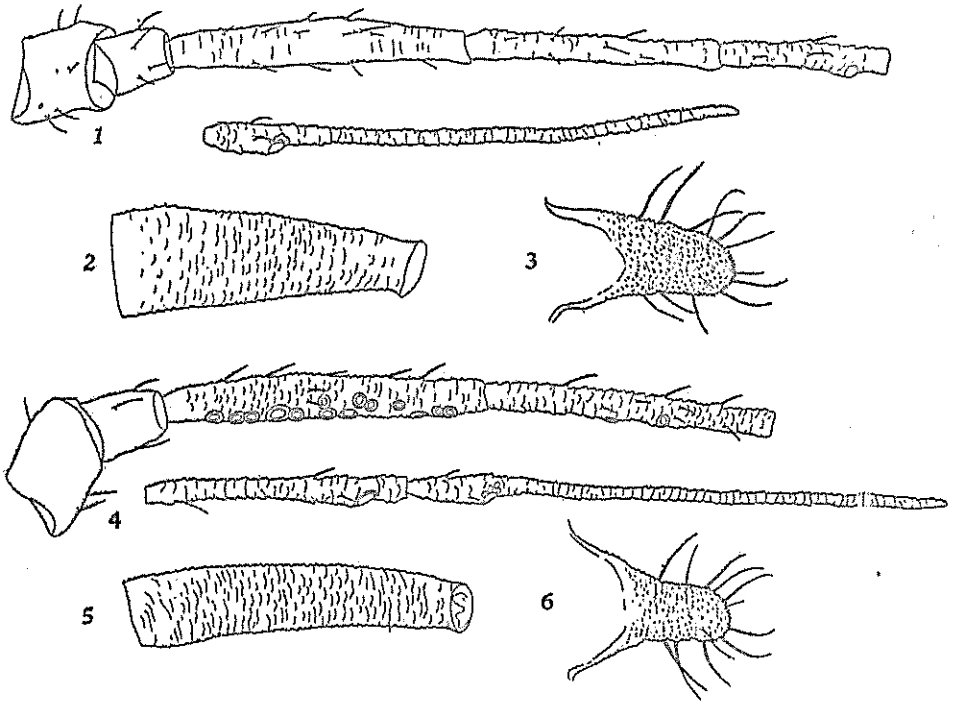

Fig. 8. *Toxoptera citricidus* (Kirkaldy)
1. 2. 3. Antenna, siphunculus and cauda of aptera; 4. 5. 6. Antenna, siphunculus and cauda of alate.

Synonyms: *Myzus citricidus* Kirkaldy, 1907; *Aphis tavaresi* del Guercio, 1908; *Aphis citricola* van der Goot, 1912; *Paratoxoptera argentinensis* Blanchard, 1944.

Hosts: Bombaceae: *Bombax ceiba* Linn.; Camelliaceae: *Camellia japonica;* Euphorbiaceae: *Bridelia monoica, Bridelia ovata;* Flacourtiaceae: *Xylosma congestum* Merr.; Lauraceae: *Cinnamomum camphora;* Moraceae: *Ficus retusa;* Rosaceae: *Eriobotrya* sp.; Rubiaceae: *Lasianthus chinensis;* Rutaceae: *Citrus* spp., *Murraya paniculata, Poncirus trifoliata, Zanthoxylum aviennae.*

It is very abundant on citrus during flush period over the island.

Distribution: China: Taiwan, Kwangtung, Yunan, Szechuan, Chekiang, Kiangsu; Corea, Japan, Lyuchu, India, Ceylon, Philippine, Hawaii, Malaya, Java, Sumatra, Fijii, New Guenia, South America, Africa. But it is still unknown from the citrus growing California, Florida of the United States and Mediterranean Area.

Among them, *Toxoptera citricidus* (Kirkaldy), *T. aurantii* (Boyer), *Aphis spiraecola* Patch and *A. gossypii* Glover have been proved as insect vectors of tristeza by both foreign and native virologists, the remaining three species, *Sinomegoura citricola* (van der Goot), *Myzus persicae* (Sulzer) and *Toxoptera odinae* (van der Goot) are not tested.

II. SEASONAL POPULATION SURVEY OF *TOXOPTERA CITRICIDUS* (KIRKALDY) AND *T. AURANTII* (BOYER)

Dr. Moericke discovered the yellow colour as the possitive tropism of aphids, using this method for surveying aphids instead of suction trap is much convenient. One Moericke yellow trap is set in Hsinpu, Hsinchu, It is carried out from February of 1959.

The structure of the yellow tray is shown as accompanying figure (Fig. 9). It is made of tin metal plate and painted with yellow colour. Two thirds fill with water, add a drop of detergent, change water, add detergent and clean bottom of tray daily or day intervals, keep and label the trapped aphids in a small glass containing with commercial alcohol, plug with absorbent cotton wool and put into alcohol bottle ready for identification.

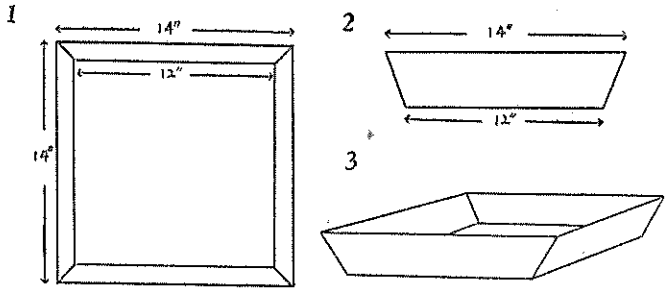

Fig. 9. Yellow tray diagram.
1. Above view, 2. Side view, 3. In use view.

Before identification, pin small holes on the abdomen of trapped specimens and soak in 10% caustic potash untill the internal contents softened and dissolved into the solution, about one day later, wash in distilled water and clear in clearing solution (saturated solution of chloral hydrate in Phenolum Liquefactum), mount in Berlese medium (gum arabic 12 g, glycerine 6.5 cc, chloralhydrate 20 g, distilled water 20 cc,. All the substance are dissolved in 40 cc cold water, filtered through glass wool and placed in incubator 30–40° C to evaporate the surplus water; the evaporation should be interrupted when the liquid has the desired visicosity) separately.

After mounting, examine under the miscroscope, if it is *Toxoptera citricicidus* (Kirkaldy) or *T. aurantii* (Boyer) put on one side and counted separately. Because of these two aphids are the major citrus pests and well known insect vectors of tristeza. The seasonal population curve is shown in Figure 10.

According to Figure 10, *Toxoptera citricidus* (Kirkaldy) is more than *T, aurantii* (Boyer) and the seasonal appearance is just the same. So far as we known, the trapped individuals come from citrus but very rarely from other hosts. There are two peak;

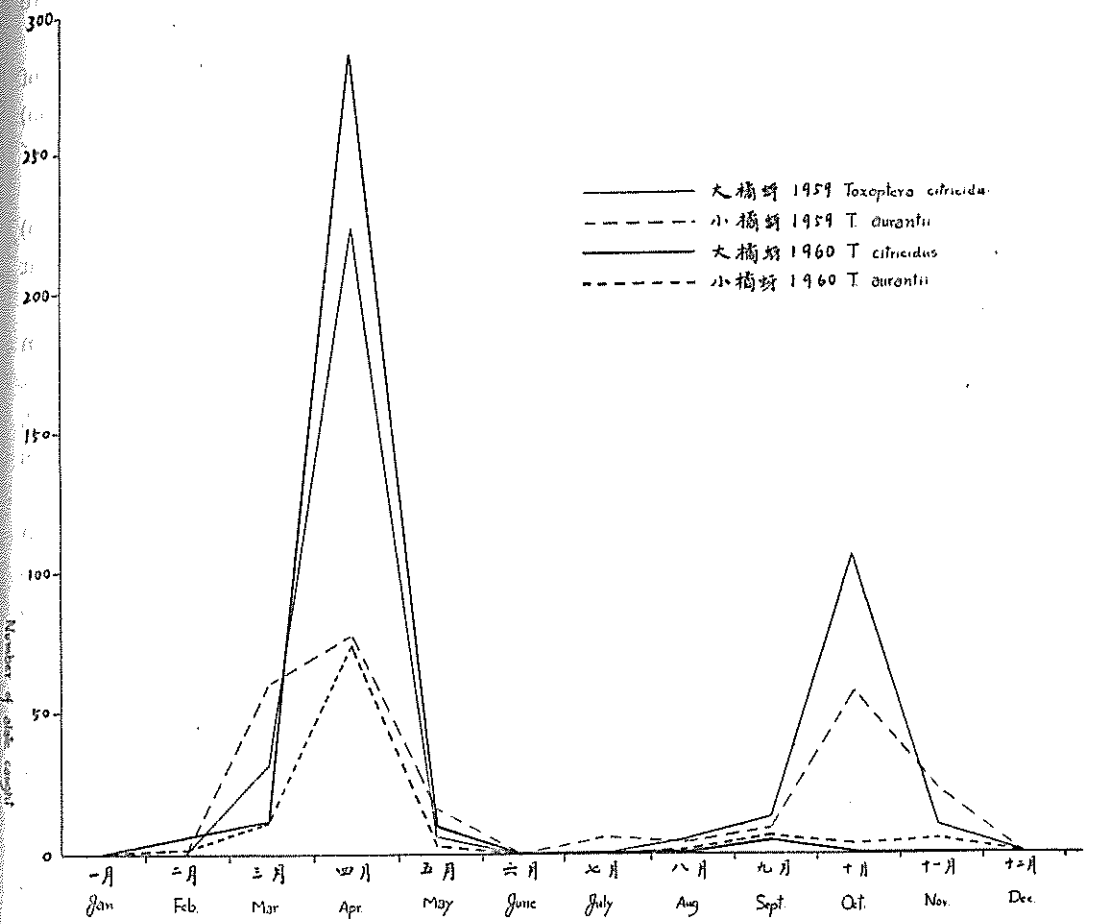

Fig. 10 Seasonal Population Survey of *Toxoptera citricidus* and *T. aurantii* at Hsinpu, Hsinchu during 1959-60.

periods, one is in April and the other in October. It cannot be used as the timing of aphicide application indicator. Proper time of aphicide application has to watch citrus flush period of different citrus species, varieties, growth and locations.

III. CHEMICAL CONTROL

Aphids are easy to be controlled with modern synthetic organic phosphorous compounds as malathion and botanical sources as rotenone, pyrethrin or nicotine sulphate and even scalicides as resin soda wash or oil is also effective. However, aphids are parthenogenetic, it completes on generation less than one week in favorite environment of temperature and nutrient, so that the reproduction is very high. If we neglect, it will cover all the tender foliage especially in spring flush period.

Moreover, Citrus standing in hillside where is hard to get sufficient water for spraying and *Aphis spiraecola* Patch lives within curl foliage thus to choice systemic

insecticides as metasystox and ekatin for more effective. The following results were obtained from the latest two years experiment.

Metasystox or methyl demeton, demeton-methyl, methylisosystox is a mixture of O, O-dimethyl O-2-(ethylthio) ethyl phosphorothioate and O, O-dimethyl S-2 (ethylthio) ethyl phosphorothioate. The ratio is 30:70. It is a Bayer product and contains 25% active ingredient in emulsive form.

Eaktin or thiometon is a trade name of O, O-dimethyl S-dimethyl S-2-(ethylthio) ethyl phosphorodithioate. It is a Sandoz product and contains 20% active ingredient in emulsive form.

Both having been tested as compared with malathion, they are much better than malathion and 0.1% metasystox or 0.05% ekatin concentration seems to be the most effective and economic. For getting better result it has to be applied in the fine day, when the plant is dried up completely and without any dew on the foliage thus making it quickly absorb and persist longer.

Bloom and flush of tristeza infested plants are irregularly but usually earlier than ordinary or healthy trees, therefore making first application on these infested plants to diminish migrants of citrus aphids fly to healthy late bloom and flush plants is the first key for reduction tristeza spreading.

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臺灣柑橘蚜蟲種類檢定和季節消長調查及藥劑防治試驗

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本文敍述本省爲害柑橘之蚜蟲共七種，即月橘蚜 *Sinomegoura citricola* (van der Goot) 桃蚜 *Myzus persicae* Sulzer，棉蚜 *Aphis gossypii* Glover，繡球蚜（捲葉蚜）*A. spiraecola* Patch，烏桕蚜 *Toxoptera odinae* (van der Goot)，小橘蚜 *T. aurantii* (Boyer de F.) 及大橘蚜 *T. citricidus* (Kirkaldy)，並有七種蚜蟲之檢別表。每種柑橘蚜蟲之同種異名、寄主（包括大陸）及分佈等，亦有扼要記述。

大橘蚜及小橘蚜爲本省最主要之柑橘蚜蟲，該二種在黃色誘蚜盆上之誘測記錄，亦有述及。一年中以四月及十月爲二個最盛期，但不能依此作爲藥劑撒佈最適時期。藥劑撒佈最適時期，須憑每次柑橘發芽期爲準。

治蚜藥劑經實地試驗結果以官能殺蟲劑中之 ekatin (thiometon) 20% ec×400 (0.05%) 或 methyl iso systox (metasystox) 25% ec×250 (0.1%) 爲最安全可靠。同時亦可防治柑橘紅蜘蛛及橘潛蛾等害蟲，因此可以提倡採用，並於晴天晨露乾後撒佈最宜，如能注意生育不正常之柑橘，先行澈底防治，收效更大。